RODRICK

30 COPIES

ZIMBABWE SCHOOL EXAMINATIONS COUNCIL

General Certificate of Education Advanced Level

PHYSICS **9243/3**

PAPER 3

Thursday **7 NOVEMBER 2002** Afternoon 2 hours 30 minutes

Additional materials:
Answer paper
Electronic calculator and/or Mathematical tables
Ruler (mm)

TIME 2 hours 30 minutes

INSTRUCTIONS TO CANDIDATES

Write your name, Centre number and candidate number in the spaces provided on the answer paper/answer booklet.
Answer **six** questions.
Answer **four** questions form Section A and any **two** questions from Section B.
Write your answers on the separate answer paper provided.
If you use more than one sheet of paper, fasten the sheets together.
All working for numerical answers must be shown.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets [ ] at the end of each question or part question.
You are advised to spend about 40 minutes on Section B.
You are reminded of the need for good English and clear presentation in your answers.

This question paper consists of 21 printed pages and 3 blank pages.

Data

speed of light in free space,	$c = 3.00 \times 10^{8}\ ms^{-1}$
permeability of free space,	$\mu_0 = 4\pi \times 10^{-7} Hm^{-1}$
permittivity of free space,	$\epsilon_0 = 8.85 \times 10^{-12} Fm^{-1}$
elementary charge,	$e = 1.60 \times 10^{-19}\ C$
the Planck constant,	$h = 6.63 \times 10^{-34}\ Js$
unified atomic mass constant,	$u = 1.66 \times 10^{-27}\ kg$
rest mass of electron,	$m_e = 9.11 \times 10^{-31}\ kg$
rest mass of proton,	$m_p = 1.67 \times 10^{-27}\ kg$
molar gas constant,	$R = 8.31\ JK^{-1}\ mol^{-1}$
the Avogadro constant,	$N_A = 6.02 \times 10^{23}\ mol^{-1}$
the Boltzmann constant,	$k = 1.38 \times 10^{-23}\ JK^{-1}$
gravitational constant,	$G = 6.67 \times 10^{-11}\ N\ m^2\ kg^{-2}$
acceleration of free fall,	$g = 9.81\ ms^{-2}$

Formulae

uniformly accelerated motion,	$s = ut + \frac{1}{2}at^2$
	$v^2 = u^2 + 2as$
work done on/by a gas,	$W = p\Delta V$
gravitational potential,	$\phi = -\frac{Gm}{r}$
refractive index,	$n = \frac{1}{\sin C}$
resistors in series,	$R = R_1 + R_2 + \ldots$
resistors in parallel,	$1/R = 1/R_1 + 1/R_2 + \ldots$
electric potential,	$V = \frac{Q}{4\pi\epsilon_0 r}$
capacitors in series,	$1/C = 1/C_1 + 1/C_2 + \ldots$
capacitors in parallel,	$C = C_1 + C_2 + \ldots$
energy of charged capacitor,	$W = \frac{1}{2}QV$
alternating current/voltage,	$x = x_0 \sin\omega t$
hydrostatic pressure,	$p = \rho g h$
pressure of an ideal gas,	$p = \frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
radioactive decay,	$x = x_0 \exp(-\lambda t)$
decay constant,	$\lambda = \frac{0.693}{t_{\frac{1}{2}}}$
critical density of matter in the Universe,	$\rho_0 = \frac{3H_0^{\,2}}{8\pi G}$
equation of continuity,	$Av = \text{constant}$
Bernoulli equation (simplified),	$p_1 + \frac{1}{2}\rho v_1^2 = p_2 + \frac{1}{2}\rho v_2^2$
Stokes' law,	$F = Ar\eta v$
Reynolds' number	$R_e = \frac{\rho v r}{\eta}$
Drag force in turbulent flow,	$F = Br^2\rho v^2$

[Turn over

Section A

Answer any **four** questions from this section.

1 **(a)** **(i)** What is meant by *linear* momentum?

(ii) State the principle of conservation of linear momentum.

(iii) Explain how the principle is linked to Newton's third law. [6]

(b) Two spheres **A** and **B** moving in the same directions as shown in **Fig. 1.1** collide elastically. Sphere **A** has mass m and speed 4u and sphere **B** has mass 2m and speed u. The final speeds of **A** and **B** after collision are v_1 and v_2 respectively.

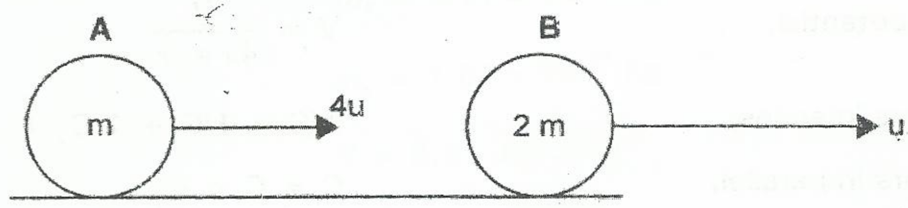

Fig. 1.1

(i) What is meant by an *elastic* collision?

(ii) Write down an equation for the conservation of momentum.

(iii) Write down an equation for the conservation of energy.

(iv) Deduce the value of v_2 in terms of u. State what happens to the motion of **A** after collision. [7]

(c) In another interaction, a plasticine sphere of mass 0.30 kg is dropped from a height of 5.00 m and sticks to the ground.

(i) Deduce the momentum of the sphere just before impact.

(ii) State and explain the transfer of energy and momentum after impact. [7]

2 (a) State **two** differences between transverse and longitudinal waves. [3]

(b) **Fig. 2.1** shows the graph of a snapshot of the waveform of a water wave. A particle **A** is 0.60 m from the origin O.

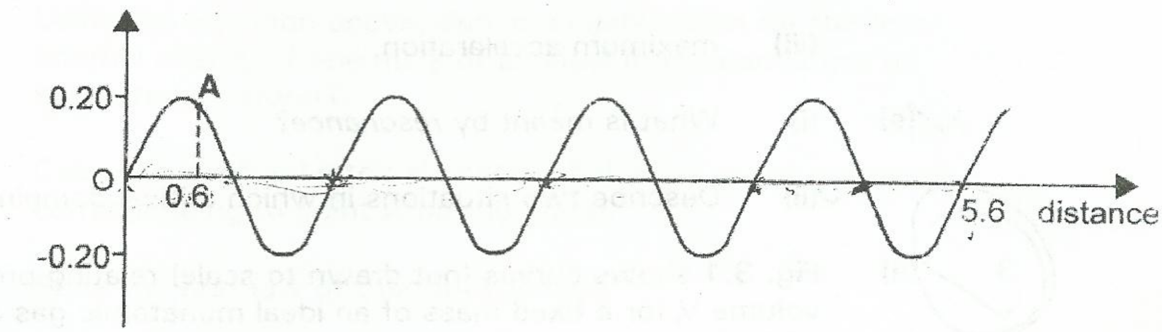

Fig. 2.1

From **Fig. 2.1** determine:

(i) the wavelength,

(ii) the phase difference between particles at O and **A**. [2]

(c) **Fig. 2.2** shows the graphs of displacement against time for the particle **A**.

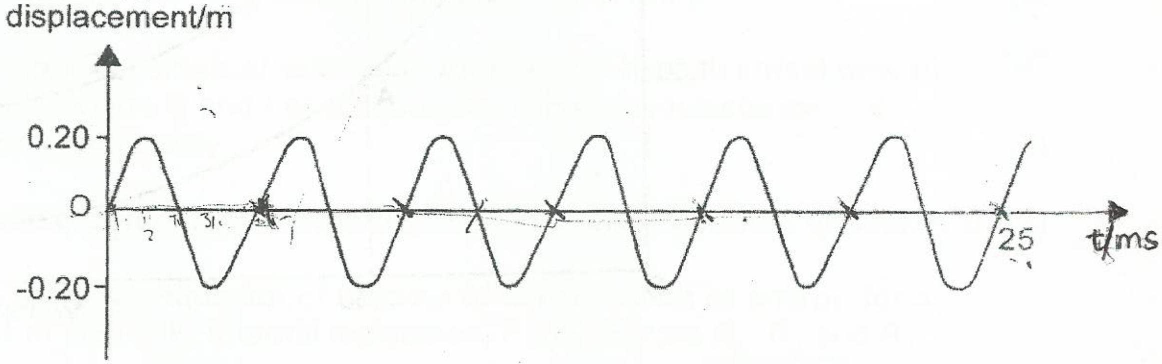

Fig. 2.2

Determine:

(i) the period, T of the oscillations of particle **A**,

(ii) its frequency,

(iii) the speed of the water waves. [5]

(d) Given that particle **A** describes simple harmonic motion, calculate its

(i) angular frequency,

(ii) maximum velocity,

(iii) maximum acceleration. [6]

(e) (i) What is meant by *resonance*?

(ii) Describe **two** situations in which critical damping is employed. [4]

3 (a) **Fig. 3.1** shows curves (not drawn to scale) relating pressure p, and volume V, for a fixed mass of an ideal monatomic gas at temperature 300 K and 600 K. The gas is enclosed in a container fitted with a piston which can move with negligible friction.

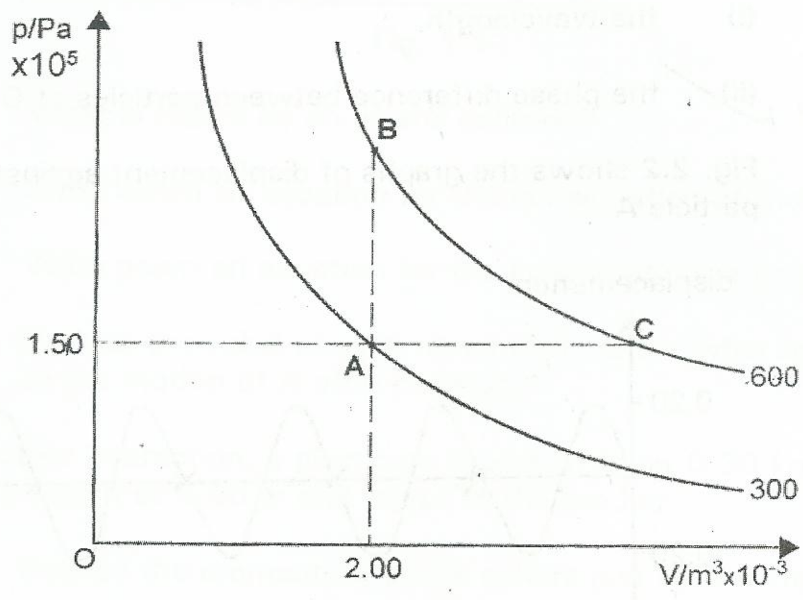

Fig. 3.1

(i) State the ideal gas equation for n moles of the gas, explaining the symbols used.

(ii) Calculate the number of moles of the gas.

(iii) Calculate the volume of gas corresponding to point C on the graph. [6]

(b) The pressure of an ideal gas is given by $p = \frac{1}{3}\rho<c^2>$ where ρ is the density of the gas.

(i) What is meant by $<c^2>$?

(ii) Using the equation above, derive an expression for the total internal energy of one mole of an ideal monoatomic gas at kelvin temperature T.

(iii) Calculate the total internal energy of the gas in the container corresponding to point **A** on the graph. [8]

(c) (i) State the first law of thermodynamics.

(ii) Using the first law of thermodynamics, calculate the heat absorbed during changes represented on the graph from **A** to **B** and **A** to **C**. [6]

4 (a) A body can be charged by friction. With the aid of a diagram, describe another method which can be used to charge an insulated metalic sphere. [2]

(b) (i) Explain how electrostatics is used to extract dust particles from chimneys of factories. [2]

(ii) Define the term *voltage* and state its SI units. [2]

(c) From your definition of voltage in **(b)(ii)** show that electrical power, $P = I^2R$, where R and I of a conductor represent resistance and current respectively. [2]

(d) State **two** differences between voltage and electromotive force(e.m.f). [2]

(e) Write down an equation of the law of conservation of energy for a circuit of e.m.f. E, internal resistance, r and resitors R_1, R_2 and R_3 connected in series. [1]

(b) The pressure of an ideal gas is given by $p = \frac{1}{3}\rho <c^2>$ where ρ is the density of the gas.

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[Turn over

(f) A light–dependent resistor (LDR) is connected in series with a 10 kΩ resistor and a 12 V d.c. supply as shown in **Fig. 4.1**.

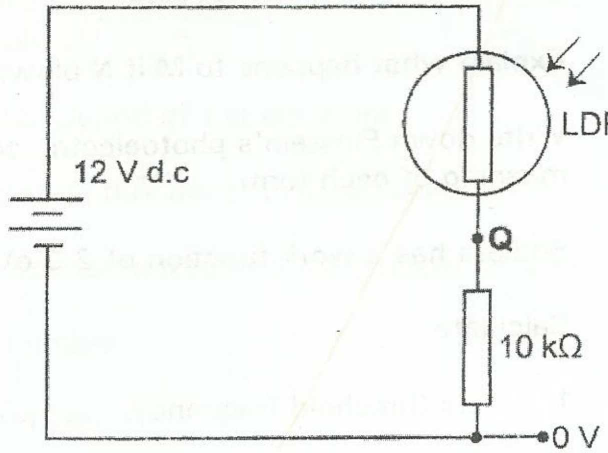

Fig. 4.1.

Find the potential at the point **Q** when the LDR is

(i) in the dark and has a resistance of 60 kΩ.

(ii) in bright sunlight and has a resistance of 2 kΩ.

(g) What is the resistance of the LDR if the potential at **Q** is 3.5 V.

(h) Two lamps **M** and **N** labelled 3 V, 0.20 A and 6 V, 0.06 A respectively, light up with normal brightness (see **Fig 4.2**).

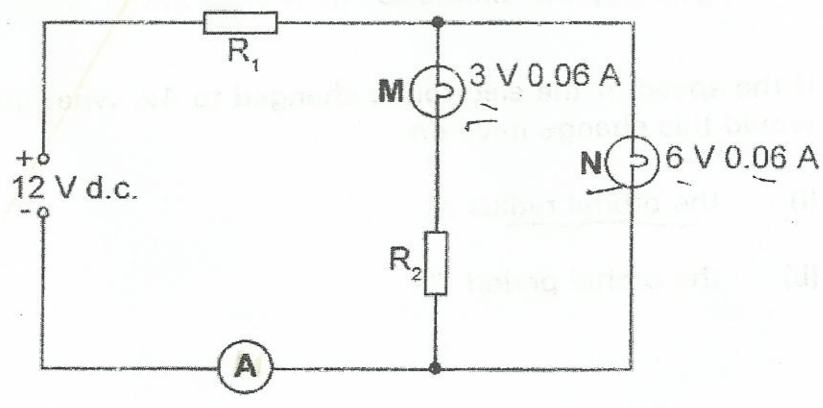

Fig. 4.2

(i) Determine the values of R_1 and R_2.

(ii) What is the ammeter reading?

(iii) Explain what happens to **M** if **N** blows out. [4]

5 (a) (i) Write down Einstein's photoelectric equation and explain the meaning of each term. [2]

(ii) Sodium has a work function of 2.3 eV.

Calculate

1 its threshold frequency,

2 the maximum velocity of the photoelectrons produced when the sodium is illuminated by light of wavelength of 5.0×10^{-7}m,

3 the stopping potential with light of this wavelength. [8]

(b) An electron travels with speed v in a circle of radius r in a plane perpendicular to a uniform magnetic fluid of flux density B.

(i) Write down an algebraic equation relating the centripetal and electromagnetic forces acting on the electron.

(ii) Hence deduce that the time T for one orbit of the electron is given by the expression $T = \frac{2\pi m}{Be}$. [:

(c) If the speed of the electron is changed to $4v$, what effect, if any, would this change have on

(i) the orbital radius r?

(ii) the orbital period T? [3

M

(d) Radio waves from outer space are used to obtain information about interstellar magnetic fields. These waves are produced by electrons moving in circular orbits. The radiowave frequency is the same as the electron orbital frequency. If waves of frequency 1.4 MHz are observed calculate;

(i) the orbital period of the electrons,

(ii) the magnetic flux density of the field. [4]

6 (a) In terms of the constituents of atomic nuclei, explain the meaning of

(i) atomic number,

(ii) mass number,

(iii) isotopes. [3]

(b) Account for the fact that, although nuclei do not contain electrons, some radioactive nuclei emit beta particles. [2]

(c) Cobalt has only one stable isotope ^{59}Co. What form of radioactive decay would you expect the isotope ^{60}Co to undergo to form ^{59}Co? Give a reason for your answer. [2]

(d) ^{60}Co decays to ^{59}Co with a half-life of 5.3 years.

(i) What is the activity of a source containing 0.015 g of ^{60}Co?

(ii) What is the activity of the source 3 years later? [

(e) The radioactive nuclei ${}^{210}_{84}Po$ emit alpha particles of a single energy, the product nuclei being ${}^{206}_{82}Pb$.

(i) Using the data below, calculate the energy in MeV, released in each decay.

(ii) Explain why the alpha particle does not take up all this energy as its kinetic energy.

(iii) Calculate the kinetic energy of the alpha particle taking the integer values of the nuclear masses. [7]

Nucleus	Mass(u)
${}^{210}_{84}Po$	209.936 730
${}^{206}_{82}Pb$	205.929 421
α - particle	4.001 504

1 unified atomic mass unit, u = 931 MeV

The Physics of Materials

(a) When steel is heated its properties change according to the heat treatment method.

Describe the following methods:

(i) annealing,

(ii) quenching,

(iii) tempering. [3]

(b) State the changes in physical properties of the material resulting from each of the processes in **(a)** above. [3]

(c) State the meanings of the terms *strain* and *stress*. [2]

(d) An athlete participated in a tug-of-war where his arm bones were under tensile stress. When he did some press-ups, his arm hands were subjected to a compressive stress. The strain-stress graph of a typical bone is as shown in **Fig. 8.1**.

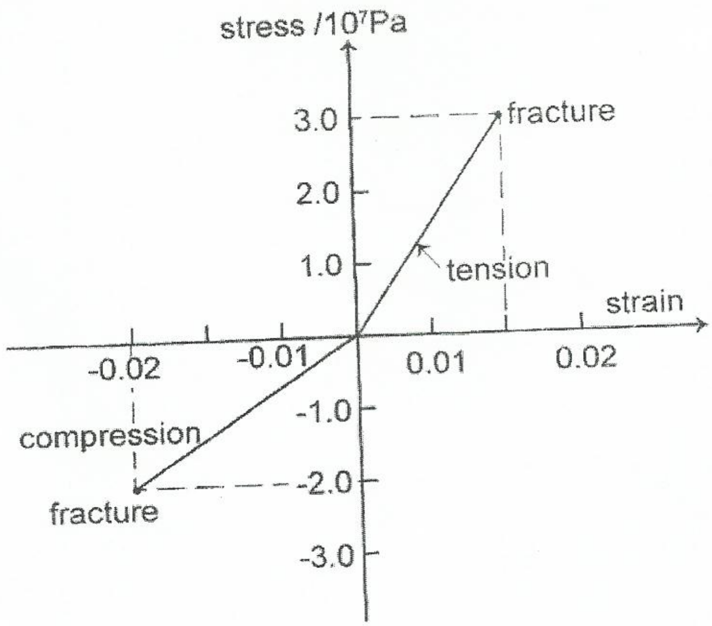

Fig. 8.1.

(i) What evidence from the graph shows that a bone is a brittle material?

(ii) Use the graph to determine a value for the Young's Modulus of the bone in compression and in tension.

(iii) If the athlete were to choose between doing press-ups or tug-of-war with others, in which activity is he safer than the other? Explain your answer. [7

[Turn o

Electronics

9 (a) (i) Describe the structure of a relay switch.

(ii) Explain how a relay switch works. [4]

(b) The output at X in **Fig. 9.1** is controlled by connecting A and B to either +5 V line or 0V line.

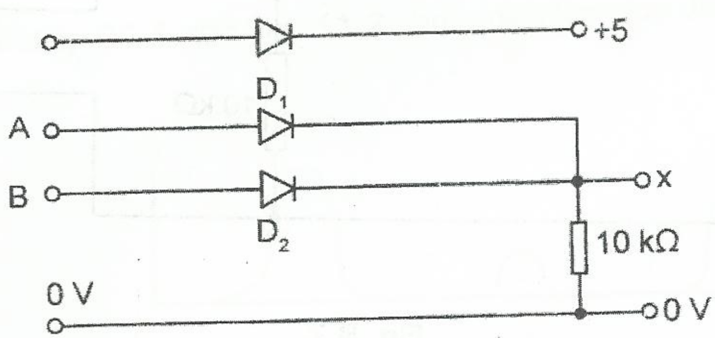

Fig. 9.1

Write the truth table of the circuit shown in **Fig. 9.1**. [3]

(c) The inputs A and B are connected to a sine wave generator of peak value 5 V, but diode D_2 is reversed in direction (see **Fig. 9.2**).

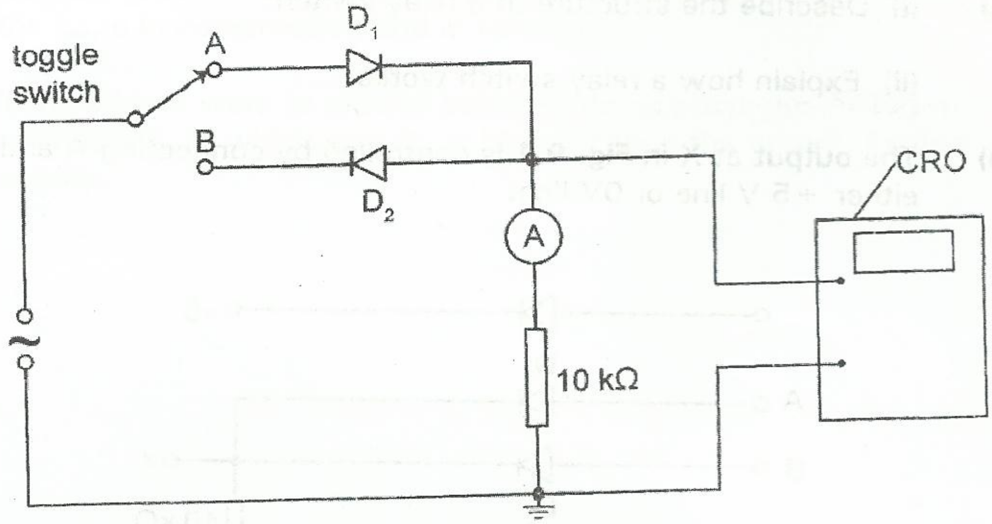

Fig. 9.2

The time of switching from A to B is equal to twice the period of the alternating voltage.

(i) Sketch a graph of the output signal on the C.R.O when the switch is at A.

(ii) Sketch another graph of the output signal when the switch is at B.

(iii) Explain your answer in **c(i)** and **c(ii)**.

(iv) What is the peak current that flows through the 10 kΩ resistor?

[Turn over

~~Option~~

Medical Physics

9 (a) (i) Explain how X-rays are produced. [3]

(ii) State and explain a way of reducing overheating of the anode. [2]

(b) X-rays cannot be focused on a screen in order to produce sharp images. Suggest and explain **two** ways of improving sharpness of images. [4]

(c) **Fig. 11.1** and **Fig. 11.2** show oscilloscope displays for scanning.

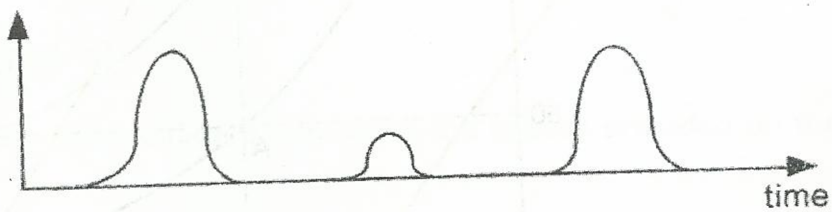

Fig. 11.1

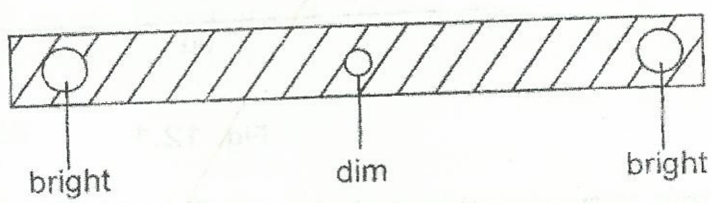

Fig. 11.2

(i) Name the scanning shown in **Fig. 11.1** and **Fig. 11.2**.

(ii) Suggest what

1. the peaks in **Fig. 11.1** show and
2. the separation of peaks in **Fig. 11.1** measure apart from time.

[redacted]

Environmental Physics

10 (a) Define the terms *isothermal* and *adiabatic* changes. [2]

(b) **Fig. 12.1** shows three lines on an indicator diagram for an ideal gas. The increases in internal energy for condition C of the ideal gas is 3.0 J.

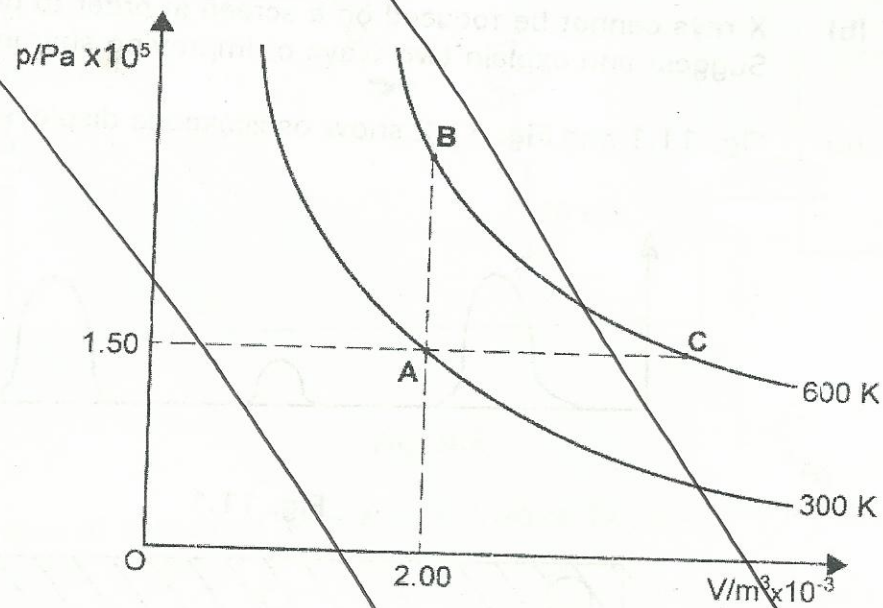

Fig. 12.1

(i) Deduce the work done and energy supplied to the gas in C.

(ii) Identify the lines labelled A, B and C. Explain your choices. [6]

(c) (i) State the second law of thermodynamics.

(ii) Suggest why an engine's efficiency is never 100% .

(iii) A car driver decides to travel from Mutare to Harare in the early hours of the morning. The driver thinks that it is good for his car. Comment on the driver's statement. [7]